DIVISION OF PSYCHOLOGY

PSYCHOLOGICAL ASPECTS OF SPACE FLIGHT*

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It was just seven short years ago that the scientific community was debating whether an active role on the part of the astronaut would help or hinder the success of a space mission. The Mercury capsule was completely automatic in its primary controls and the astronaut need not have lifted a finger from blast-off to splashdown—that is, provided everything went well with the automatic system. At the time of the debate, there was also considerable doubt in some quarters about the psychological capability of the astronaut to perform adequately in space under conditions of weightlessness. But as everyone knows, more than half of the space missions would not have achieved their objectives had it not been for the skillful, sure-handed, and clear-headed behavior of the astronauts while operating in emergency situations. It is now commonplace to assume that the success of a space mission is intrinsically dependent on the information-processing, decision-making, and highly adaptive capabilities of the astronaut who is required not only to manage and control the spacecraft and its systems, but also, in an emergency, to insert himself as an intelligent override within those automatic but not perfectly reliable systems. In brief, over and above his role as an observer, the astronaut is an essential psychological link in the control loop of the space mission.

Psychological considerations, however, are involved in every critical phase of the manned space flight program—in the selection of astronauts, in their training, and in their behavior during actual space flight.

SELECTION OF ASTRONAUTS

The principles involved in the selection of astronauts are clearly defined in the Candidate Evaluation Program (Wilson, 1959) which produced our first group of seven astronauts. The pool of potential candidates were qualified jet pilots with more than 1,500 hours of flying time, graduates of test-pilot school, in excellent physical condition, less than 40 years of age, and less than 5 feet

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11 inches in height.* From over 500 names obtained from the Department of Defense, 32 reached the final phase of the selection process which involved comprehensive physical, physiological, biochemical, medical, and psychological examinations.†

As for the psychological requirements, the search was for an individual with a high degree of intelligence, preferably characterized by mathematical and spatial aptitude. He was to be sufficiently creative to contribute not only to the development of test and space hardware, but also to the planning necessary for the success of the space program. With an ability to work closely with others, he was expected to tolerate extreme isolation without anxiety. Though reliable and consistent in his behavior, he was to possess the necessary flexibility and adaptability to meet any emergency without psychological disintegration. Deliberate rather than impulsive, and with outstanding capacity to tolerate stress, his motivation for volunteering in the space program was to be mission-oriented rather than based on a personal need for achievement. These exemplary psychological requirements were evaluated in several psychiatric interviews, with many psychological tests, and by observations of performance under stressful test conditions.

Upon completion of all physiological, psychological, and biochemical tests at the Aerospace Medical Research Laboratory, the primary group of astronauts was selected by the Candidate Evaluation Committee. Because the emphasis on psychological behavior may come as a surprise to many, the first three recommendations are presented as they appear in the concluding chapter of the report:

1. Psychological stability is the most important consideration in evaluating a candidate. The intelligence, maturity, and motivation of a candidate are vital areas to be assessed before rendering a recommendation.
2. Excellent physiological performance was a secondary consideration in the final Committee recommendations.
3. The main value of a severely stressful physiological test was the interpretation of the psychological response to that stress test. Whenever a subject terminated a severe test for psychological reasons, he was not recommended by the Committee. (Wilson, 1959, p. 99)

As if to underline the implications of these recommendations, the abstract of the report concludes: "In the final candidate recommendation psychological attributes outweigh physiological attributes." (Wilson, 1959, p. iii)

At first glance, it would appear that there is an exaggerated importance attached to psychological characteristics. And one might well ask, "Why this emphasis by the Candidate Evaluation Committee?" The Committee Report provides no explanation, but the answer may be fairly simple. The final selection was made from a physiologically homogeneous population. Active test pilots are undoubtedly in excellent physical condition. Further, one would expect that medical checkups are relatively routine procedures for this group.

*An extension of the Manned Space Flight Program includes scientist-astronauts with somewhat different qualifications. Selection for this program is in large part administered by the National Academy of Sciences. Confer also North (1965).

† Some minor changes have evolved in the testing and examination phase of the selection process (Berry, 1964).

Consequently, they would be superior specimens with very little variation from the high physiological standards prescribed for test pilots. But since they were not preselected on the basis of psychological characteristics, the candidates would naturally be expected to vary more widely and be more discriminable on these behavioral variables. But whatever the explanation, it is quite evident that psychological aspects play a critical role in astronaut selection.

ASTRONAUT TRAINING

The selection of the astronaut is not completed once his training has begun, for training can be considered as an ongoing selection process in depth. Although the purpose of careful selection is to minimize training requirements, the tremendous complexities involved in space flight and the continuing improvements in engineering hardware make the task of training even the highly selected astronaut a formidable one. Not only does he have to know his space vehicle and its operation, but he also has to be grounded in the fundamentals of space science. He receives instruction in academic subjects, such as astronomy, aerodynamics, navigational techniques, guidance and control, communications, physiology and environmental systems, and others. In addition he chooses a specialty area, the most recent developments of which he has to master and ultimately transmit to his fellow astronauts. He even becomes a scientific collaborator—as an observer, an experimenter, or a subject. But his most critical function is to be available as the ultimate redundancy factor, serving as a backup and override for a wide variety of control systems. (For a more extended treatment see Eckstrand & Rockway, 1961; Panel on Psychology, 1961; Slayton *et al.*, 1966; Voas *et al.*, 1963.)

It would be trivial to present the obvious and traditional psychological aspects of any training program, such as the enumeration of well-tested learning principles in the training of skills, or the application of a human-factors approach in the design of the operating space within the capsule. What is more important is the fact that certain basic attitudes and inner psychological controls had to be strengthened and reaffirmed in a training program that was directed towards activities and experiences the instructors themselves had never practiced nor endured. In fact, there could be no clear criterion by which one could determine that the astronaut had learned to do what he had not even tried once, nor yet experienced in space. Nevertheless, the astronaut had to be prepared to face the unknown and to become acquainted with as many of its partial features as simulation could provide.

There is an emphasis in the training program on developing those mental attitudes in the astronaut that would enable him to cope with and adapt to the known and unknown stresses of space flight. One of the essential attitudes is confidence. Correlative with the development of a healthy confidence in his space vehicle and in its related support systems are those aspects of training that prepare the astronaut to control his anxiety under conditions of stress and danger. With the attainment of necessary skills, the development of confidence, and the control of anxiety, the astronaut is more likely to maintain his information-processing capacity, his adaptability, and his decision-making capability at levels of efficiency adequate to cope with stressful and emergency situations.

But how are these fundamental psychological attitudes inculcated during the training program? Confidence is supported and maintained in many ways. The astronaut soon becomes aware of the ever present and comforting factor of redundancy which is built into those systems of the spacecraft related to crew safety—and this despite his antecedent knowledge of the exhaustive reliability testing to which all components and systems have been subjected. The far-flung communications network and an elaborate and extensive recovery system are also reassuring. Having to learn to adapt to all anticipated stresses, even though in simulated form, generates within the astronaut a faith in his own capacity to tolerate the stresses when they are actually encountered in space flight. The varied aspects of overlearning, those behavioral counterparts of instrumental redundancy, also induce realistic feelings of security, since what becomes imprinted and somewhat automatic need not be attended to and becomes relatively impervious to disruption.

Management and regulation of anxiety is established by means of comprehensive training in diagnosing and correcting simulated system failure and malfunction. Egress, escape, and survival training drastically reduce several basic sources of anxiety. The impact of simulated stresses attenuates the fear of the unknown through knowledge and experience.

These, then, are the various procedures which develop in the astronaut the basic attitudes on which so much of the success of the mission depends. Without confidence in himself and his vehicle, the individual could be easily overwhelmed by disruptive anxiety which, in turn, would seriously limit his flexibility and adaptability for coping with a stressful or dangerous situation.

BEHAVIORAL ASPECTS OF SPACE FLIGHT

Short Term Space Flights

No matter how good the selection or how careful the training of the astronaut, it is impossible to anticipate all the contingencies of actual space flight. The psychological reactions to the simulated stresses, while operating within the safe confines of the training device, cannot be the same as the vivid experiences of launch, orbital flight, and reentry. Neither the pattern nor the interaction of the stresses of actual space flight can be completely duplicated in the best simulation trainers available today. Even a single stress, such as weightlessness, cannot be reproduced in any earth-bound simulator nor maintained for any considerable period of time in aircraft flying Keplerian trajectories.

Weightlessness is a good example of a factor about which not much is known. Yet the protean character of its assumed effects has been and continues to be the source of much speculation and concern among space investigators. At one time or another it was claimed that weightlessness would induce anorexia, cardiovascular deconditioning, decreased g-tolerance, demineralization of bones, disorientation, euphoria, fatigue, gastrointestinal disturbances, hallucinations, muscular incoordination, muscle atrophy, nausea, restlessness, sleeplessness, sleepiness, and urinary retention. Also, antecedent to actual space flight, there were many dire predictions as to the specific psychological impact that weightlessness, alone or in combination with confinement and isolation, would have on the behavioral equilibrium of the astronaut. Among

the behavioral effects, confusion, disorientation, perceptual distortion, hallucinations, illusions, anxiety, "break-off" experience, and other unpleasant reactions or derangements were anticipated. But the Mercury and Gemini flights have eliminated much of the concern scientists have had regarding the possible detrimental effects of weightlessness (Berry *et al.*, 1966). Some physiological factors, such as cardiovascular deconditioning, need further intensive study, particularly with respect to the development of effective countermeasures (Vinograd, 1966). But as for psychological aberrations, none have been encountered and none are now anticipated on any of the future space missions of relatively short duration.

Although dramatic psychological disturbances have not appeared, there still remains the important question of whether the behavioral capabilities of man deteriorate under the impact of the stresses of space flight. Among these capabilities, particularly relevant to the success of a space mission, are those broad psychological categories of information processing, adaptability, and decision making. Of the three categories, information processing is a necessary condition for effective adaptability and sound decision making, and occurs at two levels. On the sensory and perceptual level, filtering and integrating activities predominate; at the rational level, inferential and predictive functions generate various alternative interpretations and project the course of present events into tentatively structured future outcomes.

In view of the fact that the main experimental emphasis of the manned space flight program has been biomedical, very little experimental evidence concerning psychological functioning is available from the present series of space flights. However, two experiments flown on Gemini V and Gemini VII provide comforting evidence that the stresses associated with a short term space flight produce no significant deterioration in visual acuity or in spatial orientation, two basic information-processing functions. In the first of these experiments (Duntley *et al.*, 1966), visual acuity was tested preflight, inflight, and postflight with a specially developed device, the sensitivity of which was equivalent to that of a clinical wall chart test. In addition, analogous rectangular patterns were constructed on large fields in Laredo, Texas, and Carnarvon, Australia, to provide an objective check on the visual acuity of the astronaut under ordinary viewing conditions from his capsule window. The patterns which the astronaut had to identify were arranged in a 4×3 matrix of 12 squares, measuring 2,000 feet on each side. White rectangular boards, varying in length from 610 to 152 feet, were randomly positioned, one in each square. Daily tests were made by the inflight acuity tester; the ground observation experiments were conducted whenever the atmospheric and capsule conditions were favorable.

The results of this experiment indicate no difference in preflight and inflight visual acuity. In other words, visual acuity during space flight was as efficient as visual acuity tested on earth. Further, there was no deterioration in visual acuity as the space flight continued, since the acuity data during the early phase of the mission were no better than those obtained just before the termination of the flight. Finally, the results of the sophisticated inflight vision tester were found to be equivalent to those obtained by the astronaut while viewing the earth patterns from his window in the speeding space capsule.

In the human otolith experiment (Graybiel & Miller, 1966), also performed

on Gemini V and Gemini VII, an attempt was made to test the horizontal vector in the absence of vision and without primary gravitational cues. In view of the fact that the otolith system is deafferentated during weightlessness, that is, the stimulus provided by the usual gravitation force is absent in flight, a secondary purpose of the experiment was to determine if otolith functioning were affected by prolonged weightlessness. The testing of the visual localization of the horizontal was done at three periods: preflight, inflight, and postflight. Otolith functioning could be tested only in the pre- and postflight conditions. The results revealed that otolith sensitivity was not significantly affected by space flight. Furthermore, "the loss of sensory information from the otolith organs and other receptor organs stimulated by gravity following transition into weightlessness did not appear to influence visual mechanisms concerned with the perceived direction of space." (Graybiel & Miller, 1966, p. 209)

Both of these experimental results are reassuring insofar as the planning of future missions is concerned. Adequate visual functioning, as for example, in the acquisition of data and monitoring of controls, is the bedrock on which the success of present space flights depends. The personal orientation of the astronaut is also critical for his effective operation in space, especially during extravehicular activity. The fact that there is no measurable deterioration in these functions indicates that time-extended exploration of space can be undertaken with greater confidence.

Although experimental evidence of behavioral reaction in orbital flight is understandably meager at this stage of the space program, the efficiency with which all astronauts discharged the formidable work load of monitoring and operating the controls, managing their life functions, experimenting, observing, recording, communicating, and housekeeping is incontrovertible evidence of the adequacy of their information-processing capability and the reliability and precision of their motor discharge functions. From the first orbital flight, the psychological reactions of all astronauts were characterized by alertness, keen perception, excellent reactivity, and good judgment. At no time was there disorientation—neither during the roll or tumble of the spacecraft nor in extravehicular activity. As far as adaptability and decision making are concerned, the prime example is the behavior of astronauts Armstrong and Scott who, in the docking phase of their mission, effected a successful disengagement from the Agena and rather quickly gained control of their malfunctioning and violently rotating spacecraft. Their behavior, in an extraordinarily distressing situation, demonstrated the coolness and efficiency with which they adapted to the alarming character of the emergency and processed the relevant information to make the appropriate decisions.

Among all astronauts the emotional and attitudinal reactions during flight presented a characteristically normal pattern. In general, they were in good mood and good humor. Under the heightened excitement of stress and emergency, the bodily resonance in the form of heart rate and respiration showed the typical pattern for such conditions. It is true that some irritability was experienced by the crew of Gemini VII towards the end of their 14-day mission, but the efficiency with which they performed their tasks was not in the least affected (Berry *et al.*, 1966).

In general, then, man has performed admirably as man in every phase of the space mission. Where failure occurred, it was technological, not human.

Long Term Space Flights

It is anticipated that the psychological impact of a short flight will be different from that of a long one. But the psychological "wear and tear" involved in a long space mission, say, for a year or so, has not yet been evaluated or assessed by experiment or simulation. Although adequately controlled on a short mission, there are many factors which can cause serious concern on flights of long duration. Three of these—confinement, isolation, and group interaction—will be given special attention because of their relation to emotional control and psychological integrity. The following discussion pertains primarily to ground-based observation and research in two types of situations: those directly relevant and those bearing some analogical resemblance to the conditions of spaceflight.

Confinement and isolation. Unless a dramatic breakthrough occurs in engineering design, living and work space on a flight of long duration will continue to be limited. When physical limitations impose severe restrictions on activity and motility, the resulting confinement becomes a stressful situation with characteristic physiological and behavioral effects. The physiological reaction, a nonspecific response to stress, involves the typical hormonal, respiratory, and cardiovascular changes (Fraser, 1966). There is also some evidence for a changed EEG pattern with a decrease in occipital lobe frequencies (Zubek & Wilgosh, 1963). (Kellaway & Maulsby, 1966, report a slight increase in theta activity, presumably associated with space flight conditions.) Within the behavioral area, there is no significant deterioration due to confinement in either intellectual or complex psychomotor functioning so long as meaningful tasks are employed and physiological responsivity is not affected. As the period of confinement increases, changes in subjective emotional reaction appear as an increase in irritability, resentment, and hostility. Discomfort, monotony, loss of meaning, and inadequate motivation would seem to be the important parameters that limit one's ability to tolerate the confinement experience.

Most of the experimental work on confinement has been limited to short periods of time, usually less than 14 days, with only a few studies going as long as 30 to 60 days. But if confinement, even for the relatively short periods of 14 to 30 days, produces the physiological and psychological effects mentioned above, serious thought should be given to planning confinement experiments for longer periods of time and under actual space flight conditions. It would be important to isolate the interactive effects of confinement and weightlessness and to indicate possible countermeasures by which detrimental physiological and psychological effects could be attenuated or neutralized.

Additional information on the effects of long term confinement and isolation can be obtained from Antarctic expeditions and the extended cruises of atomic submarines. Although the confining effect in these situations is a restriction to a specific locale rather than a severe limitation of gross mobility or activity, it is interesting to observe that the most frequent complaint of submariners is "confinement." The effect of prolonged submergence is indicated by an increase in tension, headaches, and sleep difficulties. In a study of morale over a 79-day period, during which the submerged atomic submarine Triton circumnavigated the world, there was a definite increase in feelings described as irritable, annoyed, disinterested, feel like giving up, bored stiff, uncomfortable, and frustrated. Despite these negative feelings, there was no

deterioration in the efficiency with which the submariners discharged their ordinary duties (Weybrew, 1963).

The effects of even longer periods of isolation are reported in several studies of Antarctic expeditions. These groups were isolated for periods ranging from five months to a year. However, there was no confinement in the sense of severe limitation on activities and mobility. In one study (Rohrer, 1961), a sequential pattern of emotional reactions was observed: an initial anxiety reaction, followed by depression, and concluded by a relatively uninhibited expression of affect in the last phases of the isolation period. In another study (Rasmussen & Haythorn, 1963), the most pronounced behavioral changes observed over a period of a year were increases in restlessness, irritability, suspiciousness, and uncooperativeness. A final report (Gunderson & Nelson, 1963) which summarized the results of three studies of behavioral reactions of men living in Antarctic scientific stations lists the three most pronounced symptoms as irritability, depression, and sleep disturbances. This report also stresses the similarity of these reactions to the experiences often reported in "sensory deprivation" experiments.

Despite the variety of work and living conditions indicated in the above studies, the behavioral reactions to long term confinement and isolation are unusually consistent. Anxiety, irritability, sleep disturbances, and to a lesser extent, depression and hostility, seem to be the most characteristic features of prolonged confinement and isolation. On the other hand, there is the puzzling outcome of ordinary tasks being performed without significant deterioration. The picture, then, is one of generalized anxiety without performance decrement.

The relevance of these studies to actual space flight conditions is not altogether clear or direct. Astronauts are carefully selected and thoroughly trained. They are also highly motivated. In these respects, they undoubtedly differ significantly from the subjects in the submarine and Antarctic studies. Furthermore, the conditions under which astronauts will have to operate are more stressful and more hazardous. And they will have to live and work under more confining restrictions. It is well known that energies can be mobilized, stress can be adapted to, and discomfort can be tolerated for short periods of time. But under conditions of continuous long term mobilization of effort against unrelenting stresses, there may well be a degradation of the resistance and adaptability of the astronaut despite the superb conditioning which he has acquired in training. The report that there was an increase in irritability towards the end of the 14-day Gemini flight would serve to corroborate in part the general findings concerning the emotional status of individuals having to work under stressful conditions in a confining situation.

Although one of the studies suggested that behavioral reactions under Antarctic isolation were similar to the experiences observed in "sensory deprivation" experiments, astronauts could not be considered as perceptually deprived on any of the space flights that have been completed. On the contrary, the problem has been one of stimulus overload rather than one of stimulus deficiency. However, in long term flights of a year or more, there is a possibility that perceptual, social, and work invariance might lead to loss of meaning and interest, which, in turn, could lead to a resurgence of basic anxiety reactions. Prophylactic measures to counter the development of invariance both in stimulus experience and in behavioral patterning would seem to be a fruitful area for experimental exploration.

Group interaction. As space flights become longer and mission objectives more demanding, the single-manned spaceship will become inadequate and will probably be relegated to ferrying and exploratory duties. Larger craft will require larger crews. But with the emergence of small multi-man crews, problems uniquely related to group functioning will need specification and resolution. In addition to the usual stresses which the conditions of space flight will impose on the individual astronaut, intimate group living and interaction within a confining spatial configuration will generate new, reciprocal, and often disturbing, social stresses among members of the crew. On the other hand, group functioning will relieve the stress of individual work loads and may gratify a number of individual needs that could not be satisfied outside of group membership. It seems clear, then, that whether they be positive or negative, the varied and complex interactive forces in group functioning will affect the morale and integrity of the group.

Getting along together within a restrictive physical environment under conditions of enforced interaction for a long period of time is no easy matter. Research in this area reveals that interpersonal relations under the above conditions become colored by irritation, conflict, and hostility. Even in highly motivated and well-disciplined two-man crews, confined in a simulated flight for periods up to 30 days, some degree of irritability and hostility was experienced by every group (Simons et al., 1963). However, these emotional reactions were generally suppressed without any measurable effect on the performance of mission duties. When overtly expressed, hostility was directed against outside personnel.

But severe physical confinement is not a necessary condition for the arousal of these emotional reactions. It was observed that irritability, hostility, and uncooperativeness also developed over time among members of the Antarctic expeditions and among submariners on extended submerged cruises of atomic submarines. In these instances there were no severe physical limitations placed on activity and mobility.

In the studies cited above, deterioration of interpersonal relations did not bring about degradation in the performance of ordinary duties. But in some studies the time periods were short, while in others the confinement was minimal. Under the unrelenting stresses and pressures of long term space flight, and within the restrictive physical confines of the spacecraft, the growth and diffusion of friction and antagonism may not always be under discipline and control.

Provocative research in this area has postulated that incompatibility is the basic reason why people find it difficult to get along with each other. They may have differing views, goals, and backgrounds. They may compete to achieve an objective only one can attain. They may fail to complement each other in personal attributes, emotional needs, or intellectual capabilities. Stated succinctly, compatibility can be best understood in terms of such notions as congruence, competition, and complementarity (Haythorn, 1963).

In an experiment evaluating the concepts of competition and complementarity (Haythorn & Altman), pairs of individuals lived, worked, and slept within a single 12×12-foot room for a ten-day period, never once leaving the room. The pairs were chosen on the basis of test results which were used to select high and low scoring individuals on such needs as dominance and affiliation. It was hypothesized that certain pairings would prove compatible and would be able to tolerate the 10-day confinement period without incident. Other pairings,

considered incompatible, were expected to experience difficulties in working efficiently for the same period of confinement. Thus, for example, the pairing of highly dominant individuals was considered an incompatible grouping. The high-low dominant pair, on the other hand, was assumed to be compatible.

For every pair that was confined, a control pair having equivalent dominance ratings was assigned within the same type of room, under the same schedule, for an equivalent 10-day period, but only for eight hours a day. At 5 o'clock they were free to leave and to continue their usual life activities in a normal unrestricted fashion.

As expected, in all but one of the confined incompatible groups, considerable irritation, conflict, and hostility developed. No such problems were found within the compatible groups. Similarly, no overt signs of hostility or conflict developed within the incompatible groups which were together only during each 8-hour work day.

It is recognized that the subjects involved in this study were quite dissimilar from astronauts in terms of age, education, professional training, and accomplishments. However, the results are suggestive and would appear pertinent to any program which must select crews to work in a harmonious and productive relationship for long periods of time. They are particularly relevant to the procedures used in selecting astronauts to serve on multiman space missions. In the past we have relied on engineering know-how to assure the compatibility of the spacecraft environment with the physiological needs of the astronauts. The above experiments indicate that analogous compatibility requirements can be socially engineered into the astronaut crew structure so as to provide a viable social atmosphere that would maximize group cohesiveness and group integrity.

Orbiting space laboratory. At several points in this discussion, specific research was recommended to clarify the many problems that have to be faced in planning extended space missions. Some of this research can and should be done on earth. However, many of the problems cannot be resolved by experiments confined solely within earth-bound laboratories. In particular, behavioral and performance norms, gathered under comfortable, gravity-oriented conditions, will not be applicable in the weightless state. Such norms can only be developed by observations and measurements on flight-crew members in actual space flight. The higher order interactions of weightlessness with the whole spectrum of space-related stresses as they affect behavioral efficiency, within the individual and within the group, will need definition and specification in the planning of future long range missions (Kubis, 1965). There is, then, an urgency in putting an orbiting space laboratory into operation at the earliest possible date. For only an orbiting laboratory can answer the fundamental questions that must be decided within the near future.

REFERENCES

BERRY, C.A. 1964. Center medical responsibilities in astronaut selection and training. Manned Spacecraft Center, NASA Fact Sheet No. 251.

BERRY, C.A., D.O. COONS, A.D. CATTERSON & G.F. KELLY. 1966. Man's response to long-duration flight in the Gemini spacecraft. *In* Gemini Midprogram Conference Including Experimental Results. : 235-261. NASA, Washington, D.C.

DUNTLEY, S.Q., R.W. AUSTIN, J.H. TAYLOR & J.L. HARRIS. 1966. Visual acuity and astronaut visibility. *In* Gemini Midprogram Conference Including Experimental Results. : 329-346. NASA, Washington, D.C.

ECKSTRAND, G.A. & M.R. ROCKWAY. 1961. Spacecrew training: A review of progress and prospects. ASD Tech. Rep. 61-721, Project No. 1710, Aeronautical Systems Division, USAF, Wright-Patterson AFB, Ohio.

FRASER, T.M. 1966. The effects of confinement as a factor in manned space flight. Contractor Report NASA CR-511, Lovelace Foundation for Medical Education and Research, Contract No. NASr-115, NASA.

GRAYBIEL, A. & E.F. MILLER, II. 1966. Experiment M-9, human otolith function: Measurements in Gemini flights V and VII. *In* A Review of Medical Results of Gemini 7 and Related Flights. : 189-249. Space Medicine Directorate, NASA, Washington, D.C.

GUNDERSON, E.K. & P.D. NELSON. 1963. Adaptation of small groups to extreme environments. Aerospace Medicine 34: 1111-1115.

HAYTHORN, W.W. 1963. Selection and training considerations for a manned space laboratory. Paper presented at AIAA/ASMA Manned Space Laboratory Conference, Los Angeles, Calif.

HAYTHORN, W.W. & I. ALTMAN. Alone together. Research Task MR022.01.03-1002, Bureau of Medicine and Surgery, Navy Department.

KELLAWAY, P. & R.L. MAULSBY. 1966. Medical experiment M008. Inflight sleep analysis. *In* A Review of Medical Results of Gemini 7 and Related Flights. : 165-189. Space Medicine Directorate, NASA, Washington, D.C.

KUBIS, J.F. 1965. Habitability: General principles and applications to space vehicles. Paper presented at Second International Symposium on Man in Space, Paris, France.

NORTH, W.J. 1965. Astronaut selection and training. Ann. N.Y. Acad. Sci. 134: 366-375.

PANEL ON PSYCHOLOGY. 1961. The Training of Astronauts. National Academy of Sciences-National Research Council, Washington, D.C.

RASMUSSEN, J.E. & W.W. HAYTHORN. 1963. Selection and effectiveness. Considerations arising from enforced confinement of small groups. Paper presented at meeting of American Institute of Aeronautics and Astronautics, Dallas, Tex.

ROHRER, J.H. 1961. Interpersonal relationships in isolated small groups. *In* Psychophysiological Aspects of Space Flight. B.E. Flaherty, ed. : 263-271.

SIMONS, D.G., D.E. FLINN & B. HARTMAN. 1963. Psychophysiology of high altitude experience. *In* Unusual Environments and Human Behavior. N.M. Burns, R. M. Chambers & E. Hendler, eds. : 127-166. Free Press, New York, N.Y.

SLAYTON, D.K., W.J. NORTH & C.H. WOODLING. 1966. Flight crew procedures and training. *In* Gemini Midprogram Conference Including Experimental Results. : 201-211. NASA, Washington, D.C.

VINOGRAD, S.P. 1966. Summary of medical experiments program; Review of findings through Gemini 7. *In* A Review of Medical Results of Gemini 7 and Related Flights. : 281-287. Space Medicine Directorate, NASA, Washington, D.C.

VOAS, R.B., H.I. JOHNSON & R. ZEDEKAR. 1963. Astronaut training. *In* Mercury Project Summary Including Results of the Fourth Manned Orbital Flight. : 171-198. NASA, Washington, D.C.

WEYBREW, B.B. 1963. Psychological problems of prolonged marine submergence. *In* Unusual Environments and Human Behavior. N.M. Burns, R.M. Chambers & E. Hendler, eds. : 87-126. Free Press, New York, N.Y.

WILSON, C.L., ed. 1959. Project Mercury evaluation program. WADC Technical Report 59-505, Project No. 7164, Task No. 71832. Wright Air Development Center, ARDC, USAF, Wright-Patterson AFB, Ohio.

ZUBEK, J.P. & L. WILGOSH. 1963. Prolonged immobilization of the body: Changes in performance and in the electroencephalogram. Science 140: 457-462.